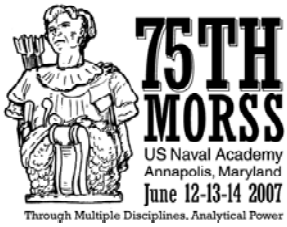

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Principal Author's Organization and address:	Phone: 937-293-3445
AFIT/ENS	Fax:
2950 Hobson Way	Email:Michael.artelli@afit.edu
WPAFB OH 45433	

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Air Education and Training Command

Replenishing the Combat Capability of America's Air Force

Public Resolve:
The Casualty of the 'Long War'

U.S. AIR FORCE

Maj Michael J. Artelli
Dr. Richard F. Deckro
Dr. Marcus B. Perry
Col Daniel J. Zalewski, PhD
Maj Sonia Leach, PhD

MORSS Presentation
June 2007

The views expressed in this presentation are those of the authors and do not reflect the official policy or position of the United Stated Air Force, Department of Defense, or the US Government

Integrity - Service - Excellence

Overview

- Problem Description
- Modeling Public Resolve
  - Simple Linear Regression
  - Mueller Model
  - Multiple Linear Regression
  - Generalized Linear Regression
    - Logistic Regression
- Implications and Future Research
- Conclusions

There are two powers in the world, the sword and the spirit.
In the end the spirit will always conquer the sword. — *Napoleon Bonaparte*

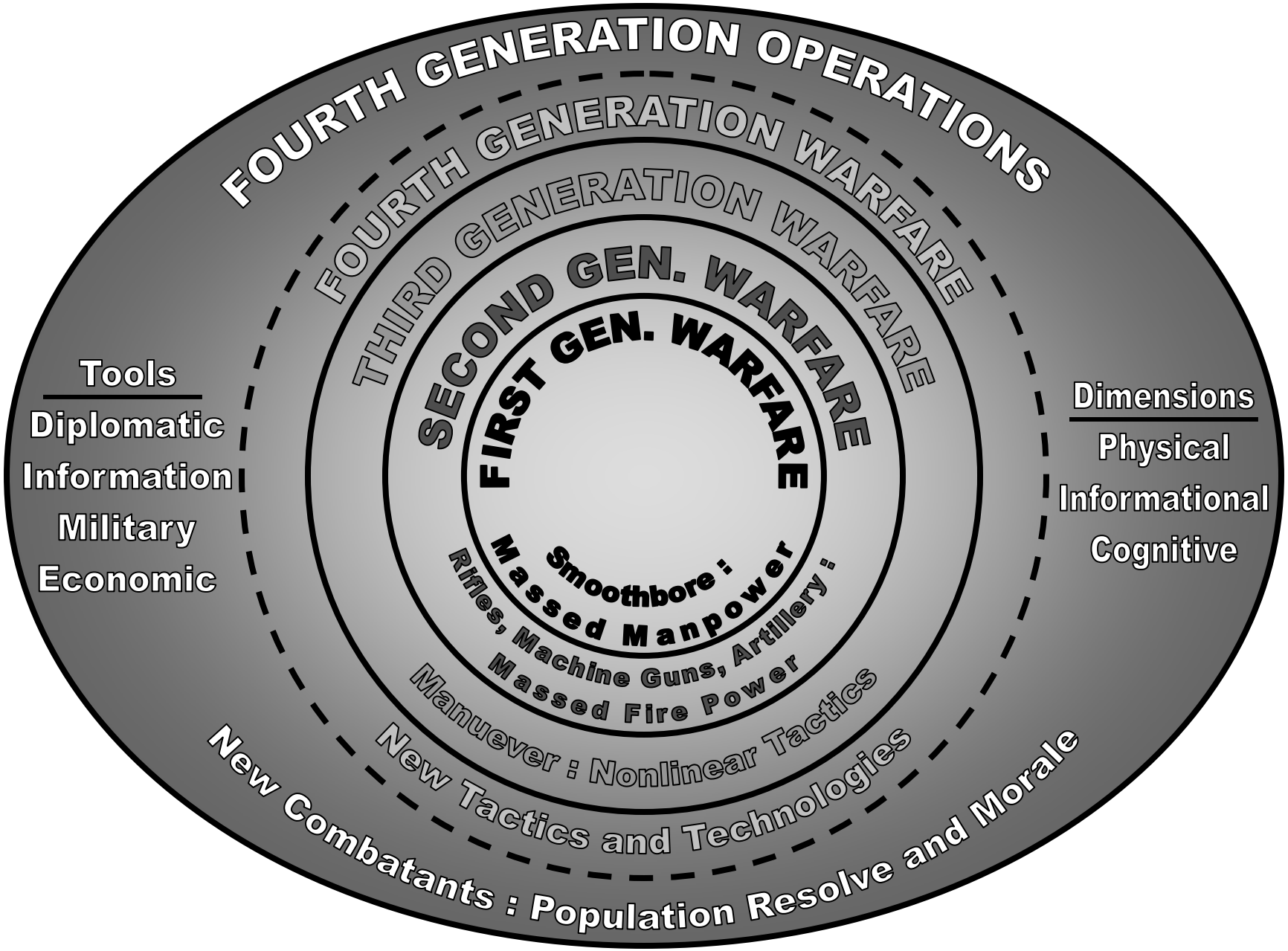
Problem Description

Shifts of emphasis from 2006 QDR

- From nation-state threats
  – to non-state enemies
- From war against nations
  – to war in countries we are not at war with
- From major conventional combat operations
  – to multiple irregular, asymmetric operations
- From static post-operations analysis
  – to dynamic diagnostics and real-time lessons learned
- From "one size fits all" deterrence
  – to tailored deterrence for rogue powers, terrorist networks & near-peer competitors

2006 QDR: Pages vi & vii

*Baghdad is the center of gravity in Iraq, and the **American people are the center of gravity for our enemies**. And what the American people believe and the American people's ability to sustain -- **what they must sustain to defeat this enemy is what our enemies are trying to influence**. – Gen Peter Pace*


FOURTH GENERATION OPERATIONS
FOURTH GENERATION WARFARE
THIRD GENERATION WARFARE
SECOND GEN. WARFARE
FIRST GEN. WARFARE
Smoothbore : Massed Manpower
Rifles; Machine Guns, Artillery : Massed Fire Power
Maneuver : Nonlinear Tactics
New Tactics and Technologies
New Combatants : Population Resolve and Morale
Tools
Diplomatic
Information
Military
Economic
Dimensions
Physical
Informational
Cognitive

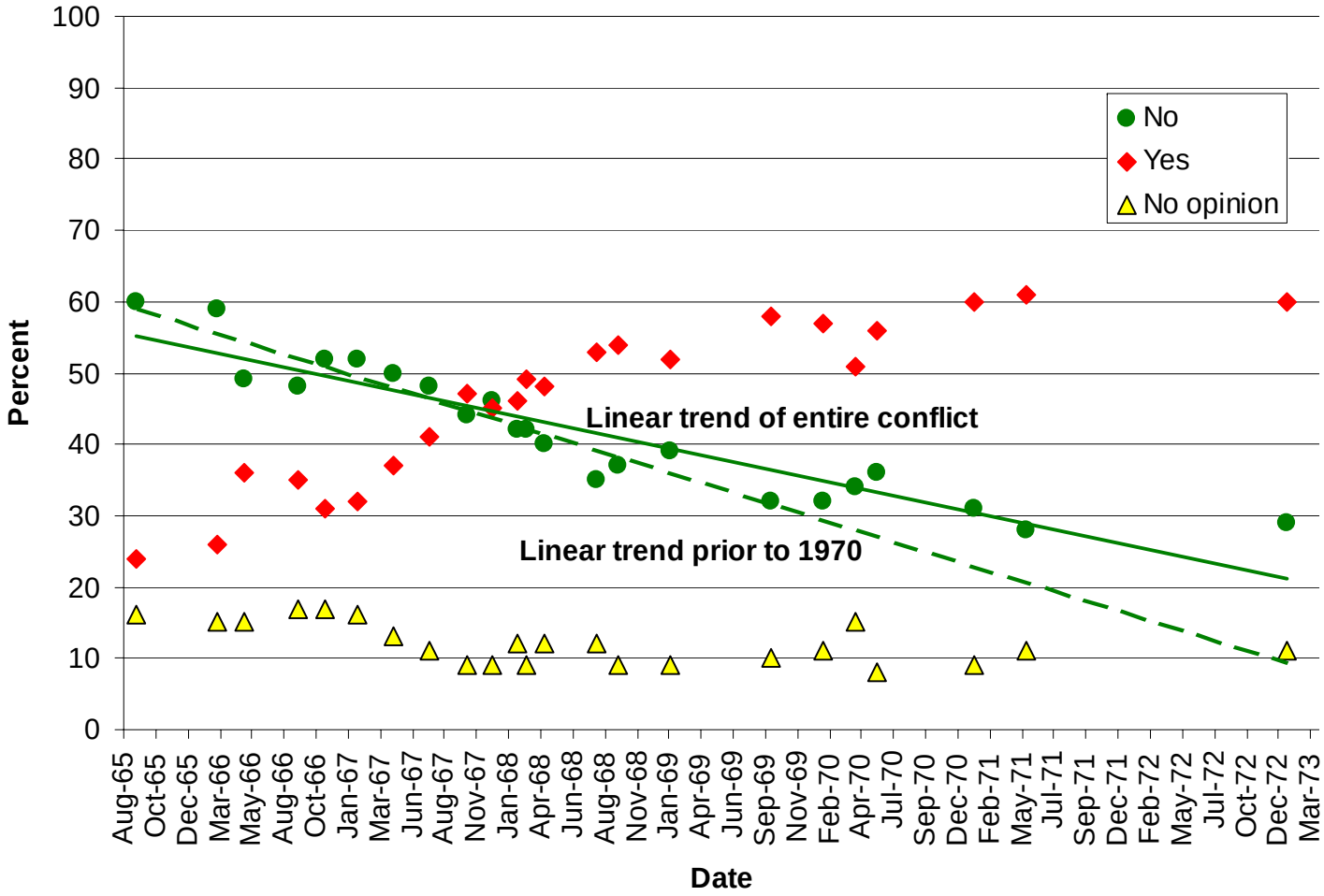
Fourth Generation Operations

Combat which combines elements of guerrilla tactics, terrorism, irregular warfare, insurgency and traditional warfare to target the will and morale of the enemy's support structure to achieve political victory

- Information Warfare only a portion of Information Operations
- Requires all tools of COCOM
  - Diplomatic, Informational, Military, Economic
- Includes all dimensions of warfare
  - Physical, Informational, Cognitive
- Currently ongoing in Iraq, Afghanistan, and elsewhere in the world

Principles of 4GO
Objective
Offensive
Mass
Economy of Force
Maneuver
Unity of Command
Security
Surprise
Simplicity
Restraint
Perseverance
Legitimacy
Population Perception

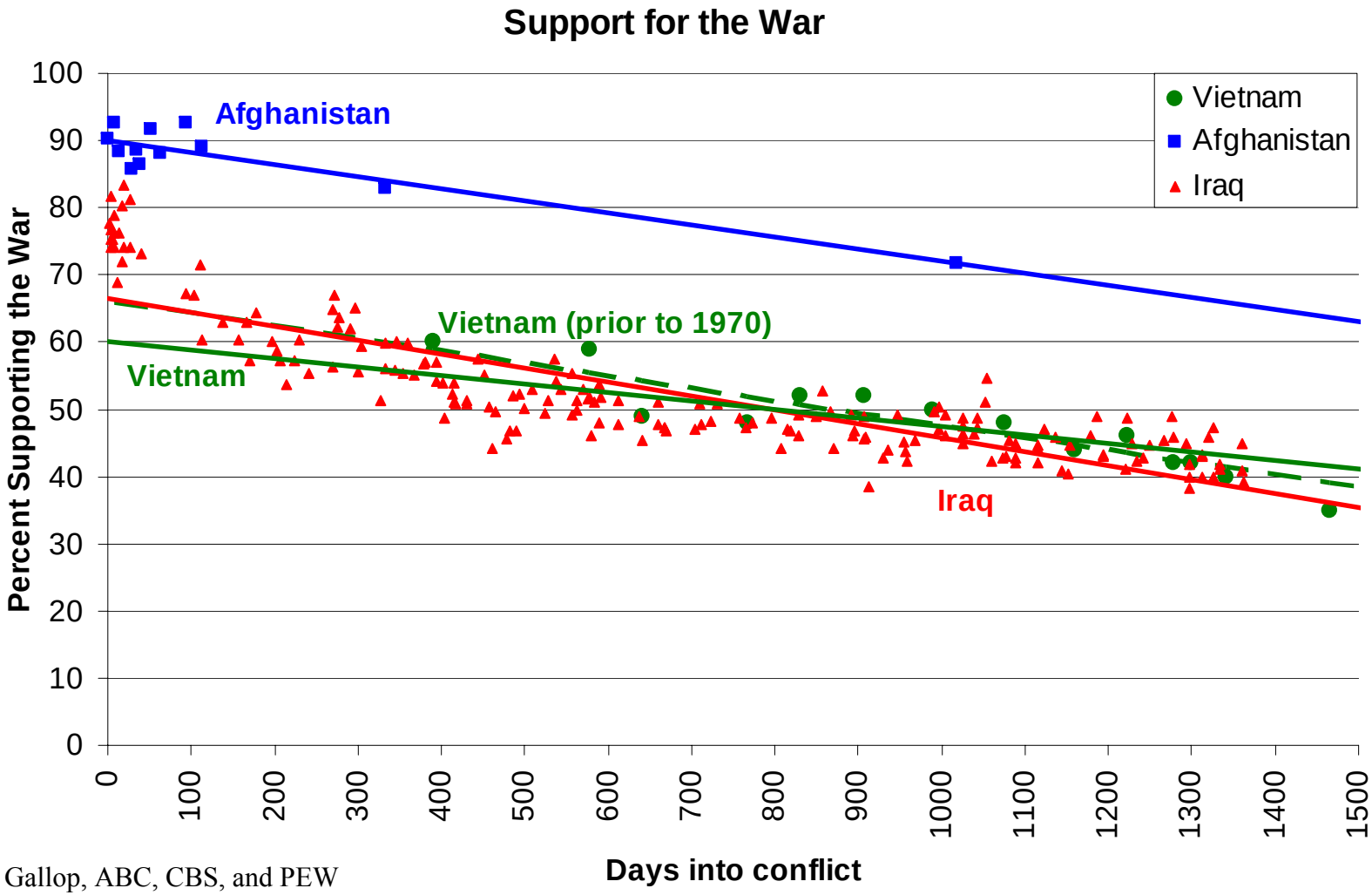
Public Support of Troops in Vietnam



- Do you think the United States made a mistake in sending troops to Vietnam?
- Solid line is fit for entire war – Dotted line is fit for 1965-1969
- $R^2 = 0.889$: $F = 120.46 > F_{16,\ \alpha=0.05} = 4.49 \rightarrow$ Adequate model

Data from Gallup Poll

Public Support of Troops in Combat



Data from Gallop, ABC, CBS, and PEW

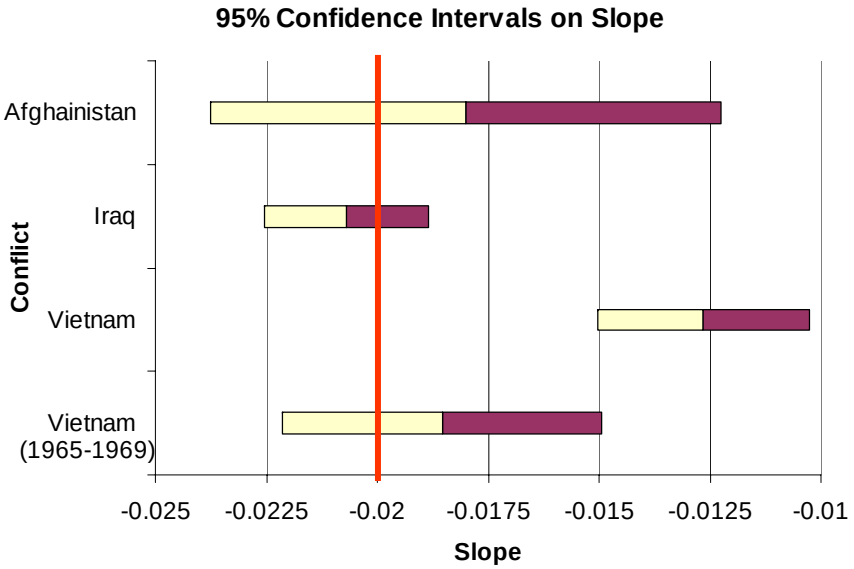
Victory is the main object of war.
If this is long delayed, weapons are blunted and morale depressed – Sun Tzu

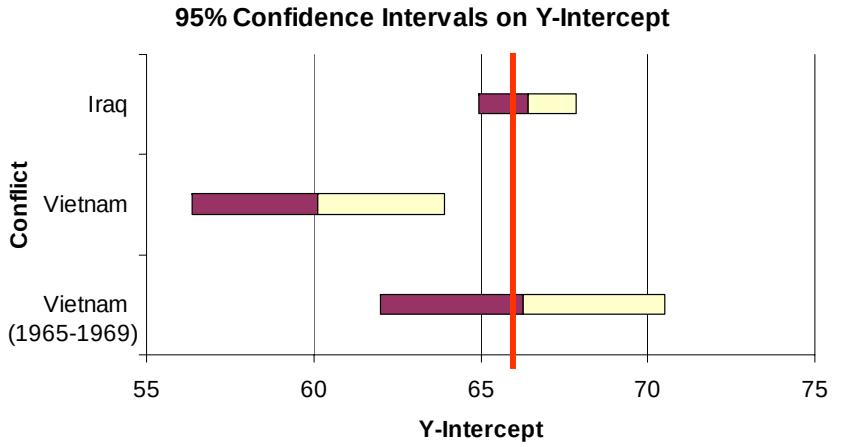
Summary of Time & Public Opinion

- Slope similar for Afghanistan, Iraq & Vietnam (1965-1969)
  - Public Support decreased 0.6% each month
- Vietnam (1965-1969) and Iraq have about the same initial support (y-intercept)
  - Same model of public support for Iraq & Vietnam for first 5 years of conflict

	Korea	Vietnam	Afghanistan	Iraq	Vietnam (1965-1969)
Y Intercept	48.55	60.12	90.04	66.40	66.26
Slope	-0.01086	-0.01265	-0.01801	-0.02070	-0.01853
R^2	0.146	0.853	0.830	0.720	0.889
Number of Data Points	11	23	12	191	17
t Test of slope	-1.24	-11.02	-6.98	-22.06	-10.98
t Statistic (α=0.05)	2.22 Fail to Reject	2.07 Reject	2.20 Reject	1.97 Reject	2.12 Reject

H_0 for *t* test was $\beta_{slope} = 0$

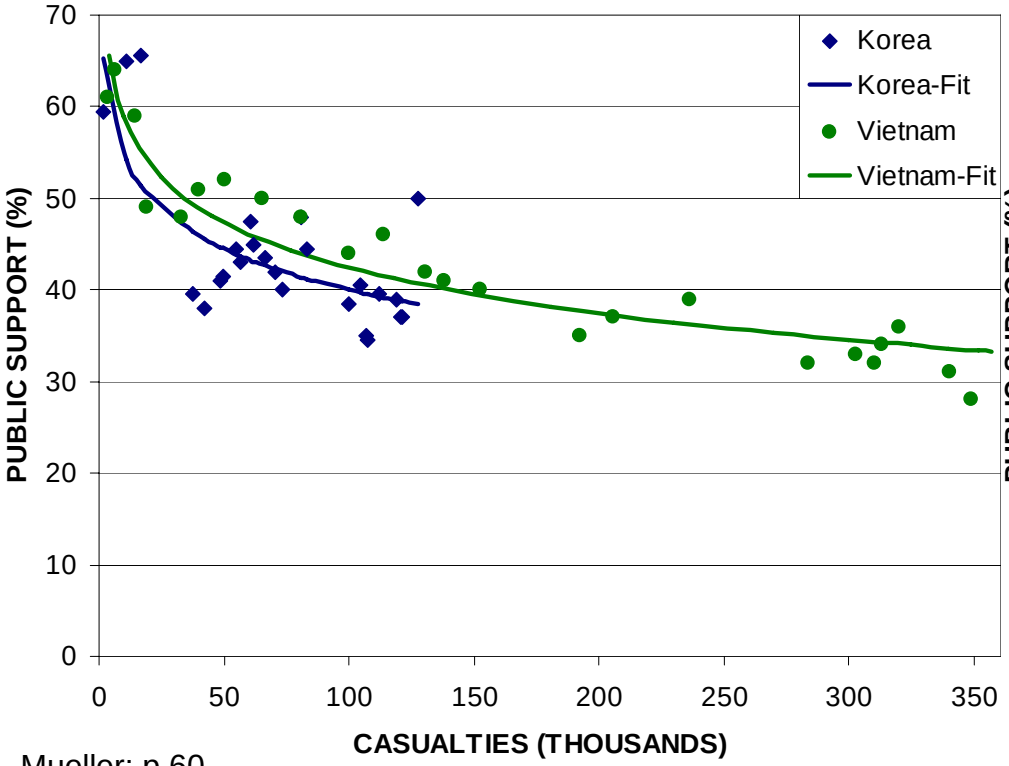


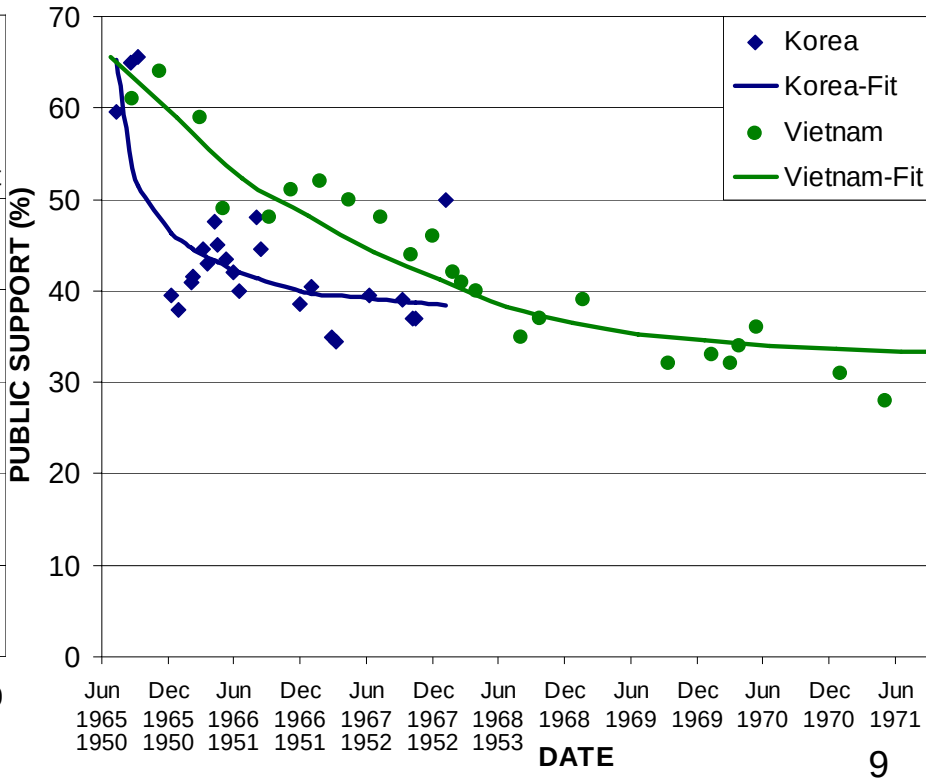


Model : *Public Support* = 66 - 0.02 · *days into war*

Mueller Model

- John Muller: *War, Presidents and Public Opinion,* 1973
- Related casualties to public opinion for Korea and Vietnam
- "Every time American casualties increased by a factor of 10, support for the was dropped by about 15 percentage points"

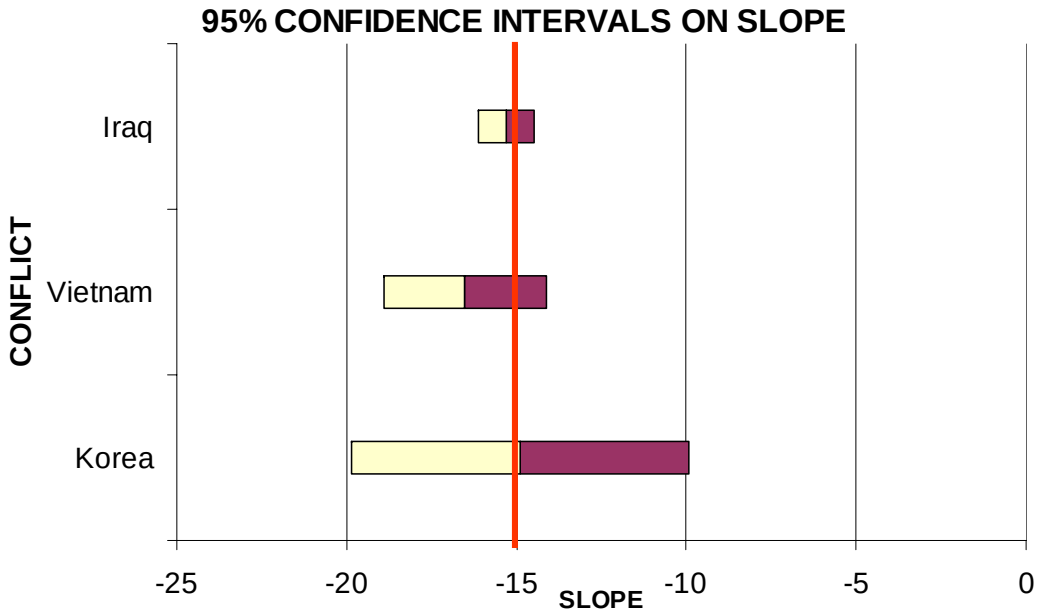




Mueller: p 60

Mueller Model Comparison

- 15% decrease of public opinion still valid
- As casualties increase, time increases



	Korea	Vietnam	Iraq
Y Intercept	114.46	124.98	110.80
Slope	-14.89	-16.51	-15.29
R^2	0.83	0.9	0.878
Number of Data Points	25	24	191
t Test of Slope	-5.35	-13.66	-22.06
t Statistic (α=0.05)	2.07 Reject	2.07 Reject	1.97 Reject

H_0 for *t* test was $\beta_{slope} = 0$

Model :

$$Public\ Support = 110 - 15 \cdot \log_{10}(casualties)$$

Multiple Linear Regression

- Days into war and log of US casualties are significant
- Are other factors important?
  # of US troops present (US)
  # of daily attacks by insurgents (Attacks)
  # of Iraqi Security Forces (ISF)
  # of insurgents captured or killed (Insurgents)
  # of foreign nationals taken prisoner
  # of insurgents
  % of foreign insurgents
  # of British fatalities
  # of Iraqi Civilians killed
  # of Iraqi Military killed
- Model structure

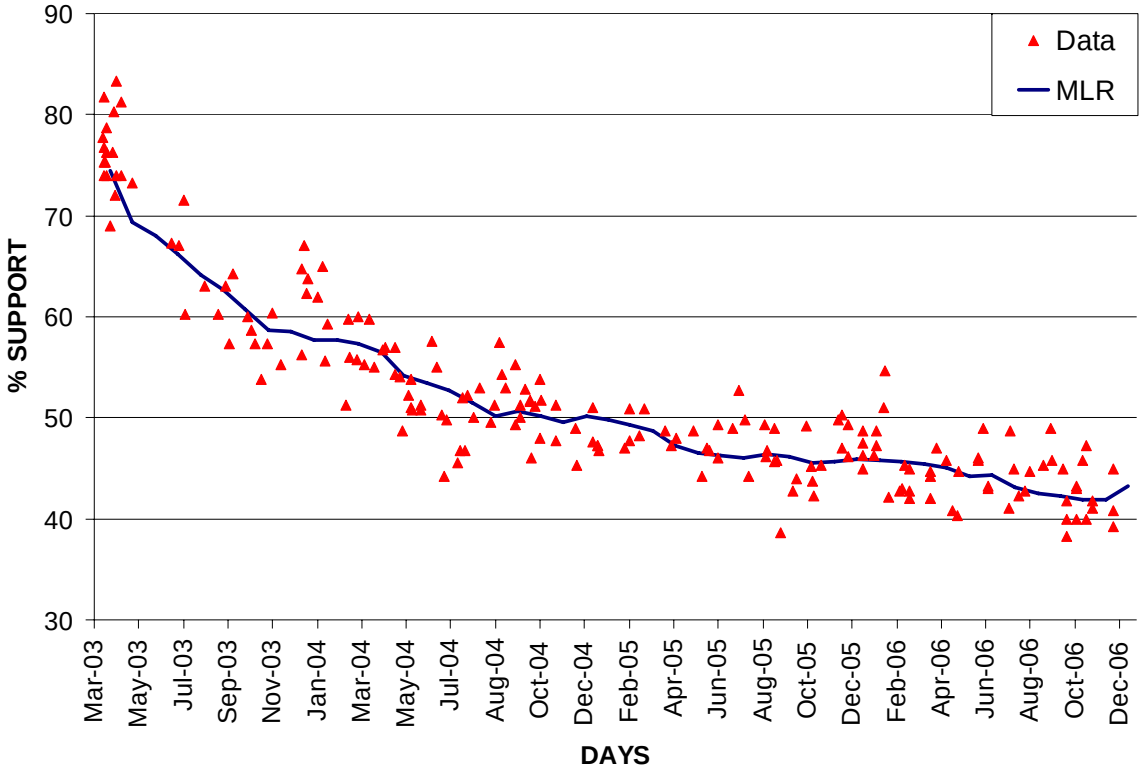
$$\textit{Public Support} = \mathbf{x}' \cdot \boldsymbol{\beta} = \beta_0 + \beta_1 \cdot x_1 + \ldots + \beta_n \cdot x_n$$

$$= \text{Intercept} + \text{coeff}_1 \cdot \textit{factor}_1 + \ldots + \text{coeff}_n \cdot \textit{factor}_n$$

In war the chief incalculable is the human will – B. H. Liddell Hart

MLR Results

- Significant factors
  - Days into war
  - Log (Casualties)
  - # of Daily Attacks
  - # of Insurgents Captured



	Intercept	*Days*	*Log (casualties)*	*Attacks*	*Insurgents*
Coefficient	**97.1151**	**-0.0473**	**-9.1137**	**-0.0344**	**0.0007**
t test of β	**24.18**	**-3.46**	**-5.37**	**-2.59**	**3.50**
t Statistic = 1.97 (α=0.05)	**Reject**	**Reject**	**Reject**	**Reject**	**Reject**

H_0 for *t* test was $\beta_{slope} = 0$

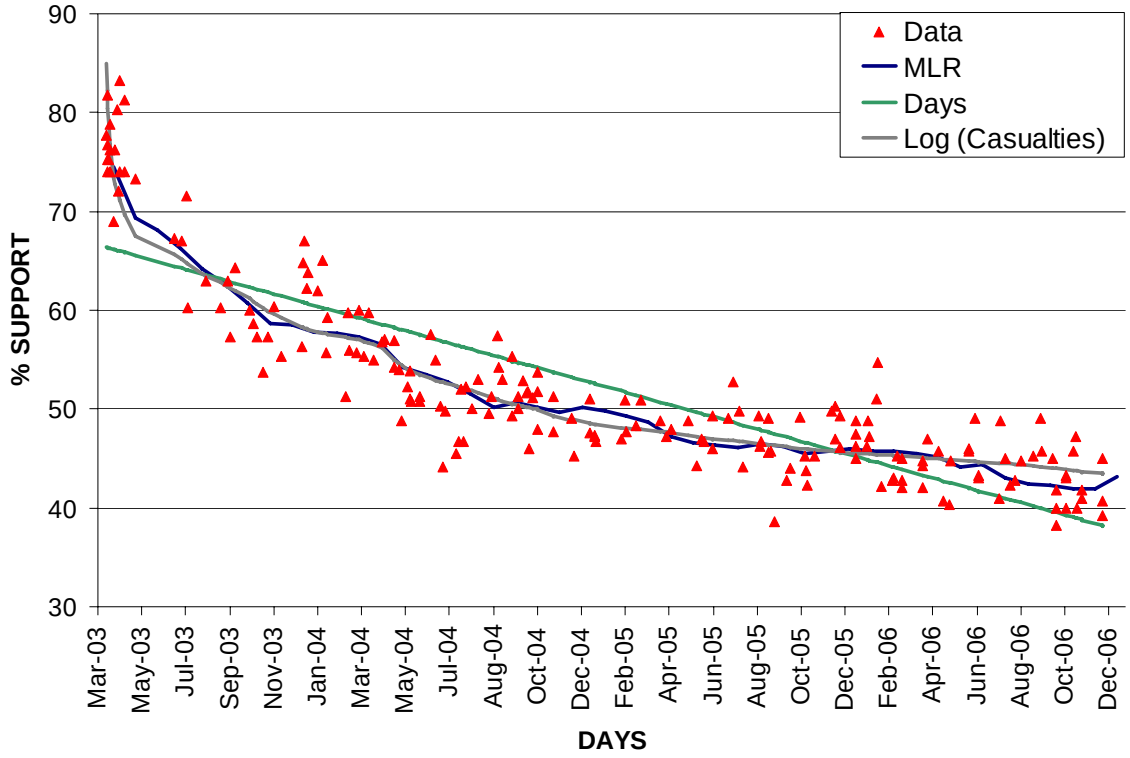
Model

$$Public\ Support = 97.11 - 0.0473 \cdot Days - 9.1137 \cdot \log_{10}(casualties) - 0.0344 \cdot Attacks + 0.0007 \cdot Insurgents$$

Linear Regression Models

- Linear fit based solely on days not a good fit
  - No support: ~8.5 years
  - R^2 (goodness-of-fit) of other models is better
- MLR and $Log_{(cas)}$ models better represent the environment

	Iraq (Days)	Iraq ($Log_{(Cas)}$)	Iraq (MLR)
R^2	0.720	0.878	0.888
Adjusted R^2	0.719	0.877	0.886
F Test	486.68	1358	369.89
F Statistic (α=0.05)	3.89 Fail to reject	3.89 Fail to reject	2.42 Fail to reject



Generalized Linear Regression

- Unifies both linear and non-linear techniques
- No requirement of normality and constant variance
- Only requires data to in the exponential family
- Logistic Regression
  - Requires data to have binary [0,1] response
  - Survey data is appropriate: binomial
  - Model structure: $E(y) = \frac{e^{x'\beta}}{1+e^{x'\beta}} = \frac{1}{1+e^{-x'\beta}}$

Montgomery, Peck, and Vining, 2001:443

Logistic Regression Model

- Each factor has been shown to be significant
  - χ indicates goodness of fit (higher → better)

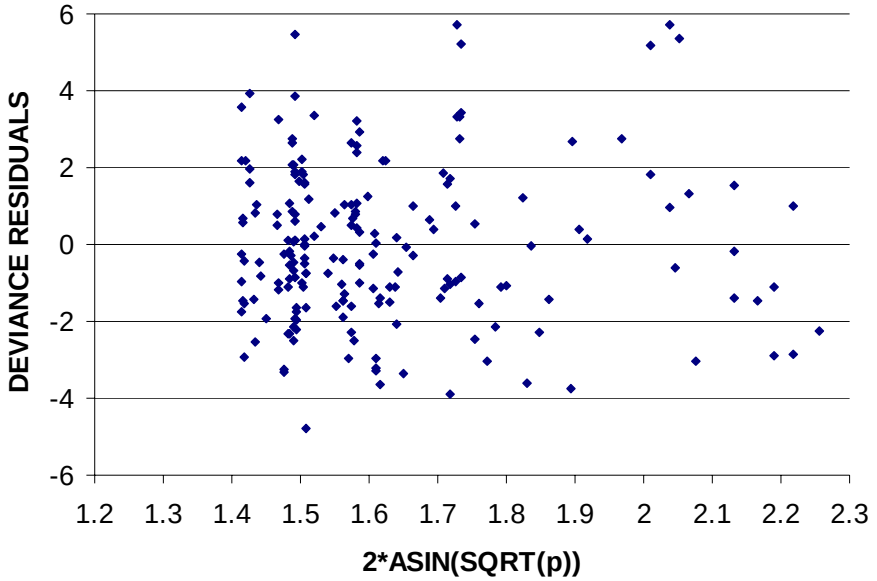
	Intercept	*Days*	*Log (casualties)*	*Attacks*	*ISF*	*Insurgents*
Coefficient	2.44	-0.00092	-0.561	-0.00129	-5.47E-07	1.65E-05
Std Error	0.10	0.00030	0.039	0.00025	2.26E-07	3.97E-06
χ Square	659.3	9.4	212.7	26.1	5.8	17.2
95% Lower CI	2.25	-0.0015	-0.64	-0.0018	-9.90E-07	8.68E-06
95% Upper CI	2.63	-0.00033	-0.48	-0.0008	-1.04E-07	2.42E-05

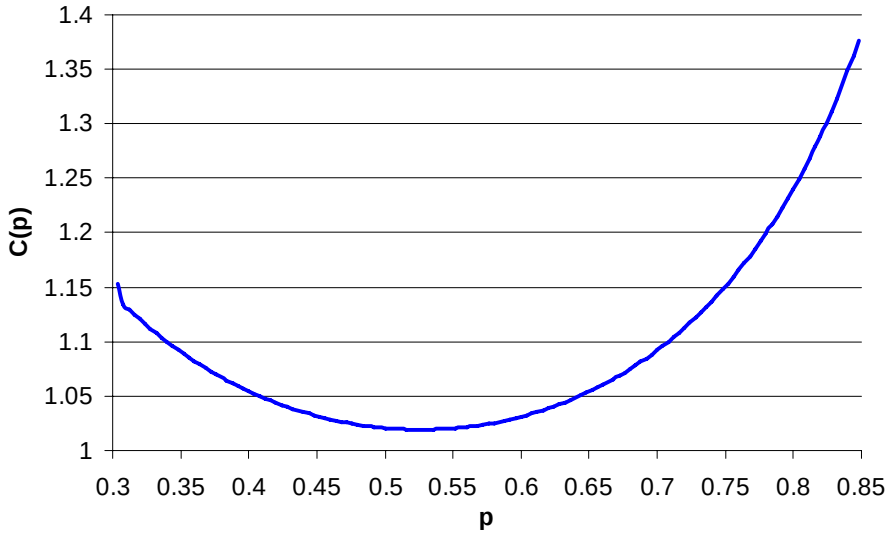
- Deviance used to show goodness of fit
  - Difference between log-likelihood of fitted & saturated model
  - Dev = 803 : $\chi_{\alpha=0.05,185}=225$
  - Model not adequate

Model Adequacy

- Two reasons for high deviance *
  - Incorrect factors
  - Overdispersion
- Transformed factors
  - Squared, log, exponential, & searched for other factors
- Reviewed residuals
- Convexity test for overdispersion^
  - Observed variance is greater than expected variance of factors
  - Plot is convex: overdisperse

$$C(p) = n^{-1} \sum_{i=1}^{n} \left(\frac{p}{\hat{p}_i} \right)^{y_i} \left(\frac{1-p}{1-\hat{p}_i} \right)^{m_i - y_i}$$





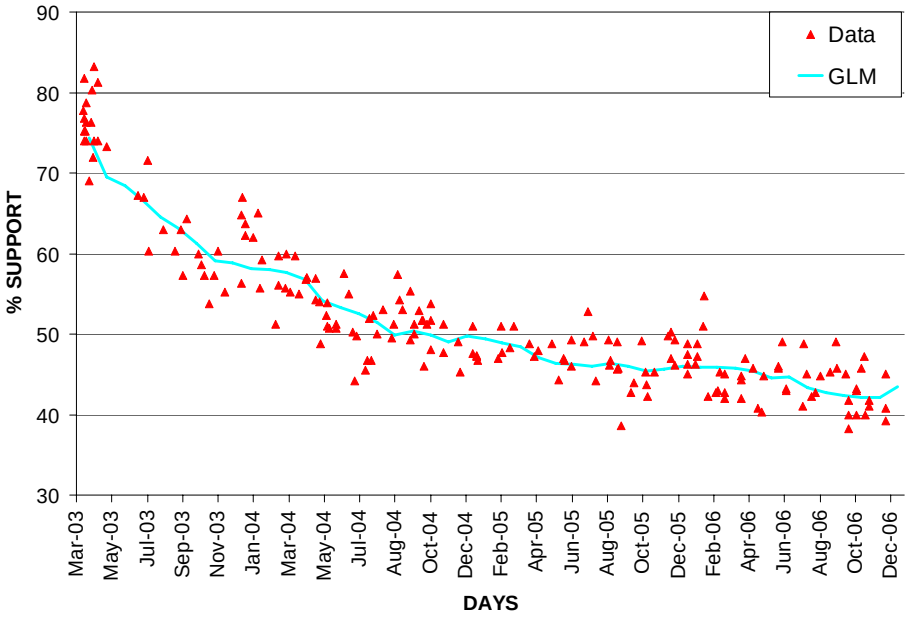
*D. Collett, Modelling Binary Data, page 194-5

^D. Lambert & K Roeder, "Overdispersion Diagnostics for Generalized Linear Models", Journal of the ASA, p 1225-1236

Logistic Regression Results

- Used Williams method for fitting overdisperse binomials
  - Model is overdispersed (dispersion factor $\Phi = 0.003627$

	Intercept	*Days*	*Log (casualties)*	*Attacks*	*Insurgents*
Coefficient	2.26	-0.00160	-0.486	-0.00151	2.41E-05
Std Error	0.19	0.00059	0.076	0.00054	8.14E-06
χ Square	155.5	7.4	41.5	7.8	8.8
95% Lower CI	1.9	-0.0027	-0.63	-0.0026	8.2E-06
95% Upper CI	2.62	-0.00045	-0.34	-0.0005	0.4E-06



Model

$$Public\ Support = \left(1 + \frac{e^{0.486 Log_{(cas)}} e^{0.0016 Days} e^{0.00151 Attacks}}{e^{2.26} e^{2.41E-05 Insurgents}}\right)^{-1}$$

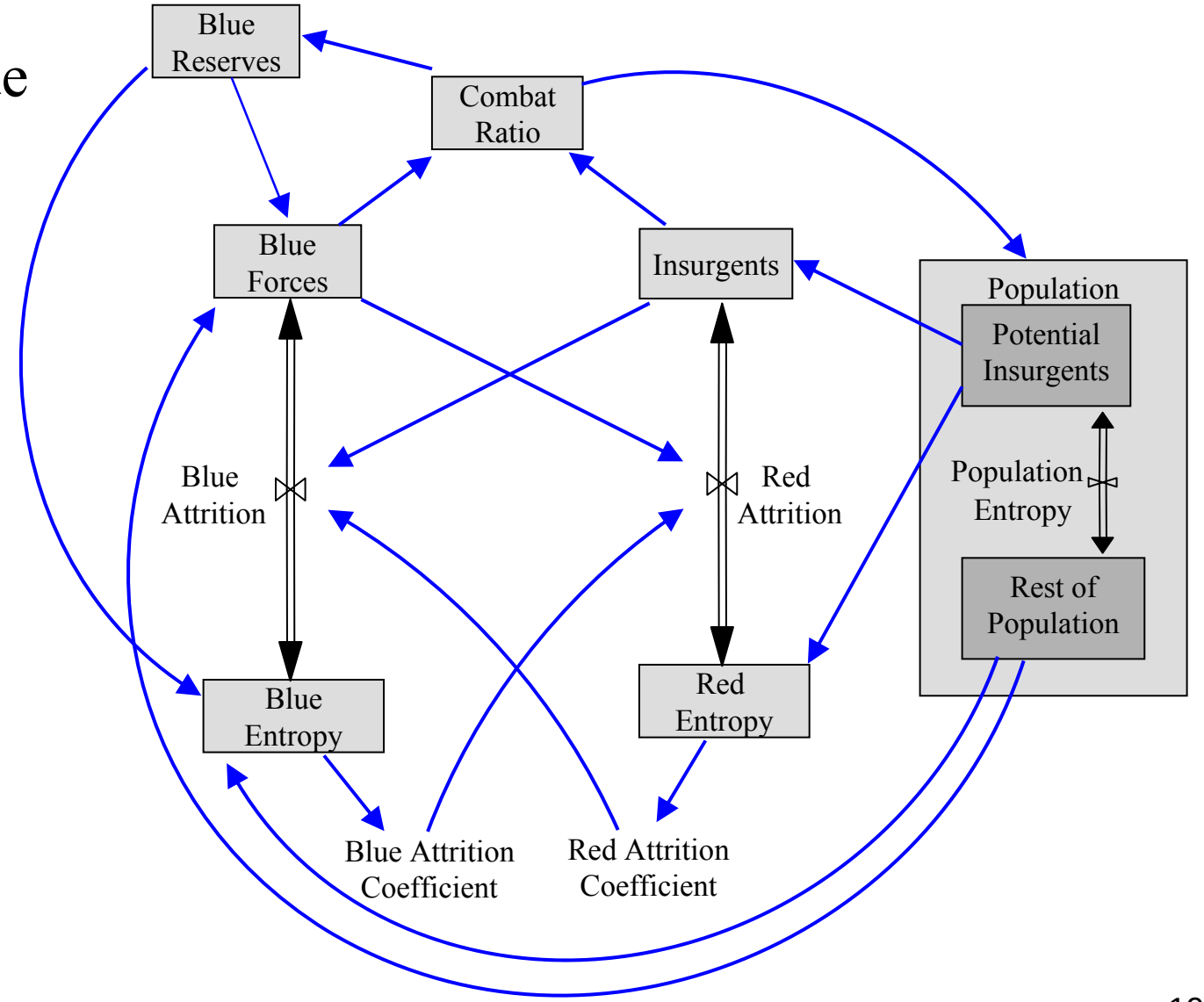
Still Valid After the Surge?

- March 25th: 43% Support (Gallop)
- April 12th: 44% Support (CBS)
- April 15th: 41% Support (Gallop)
    - Average: 42.6%

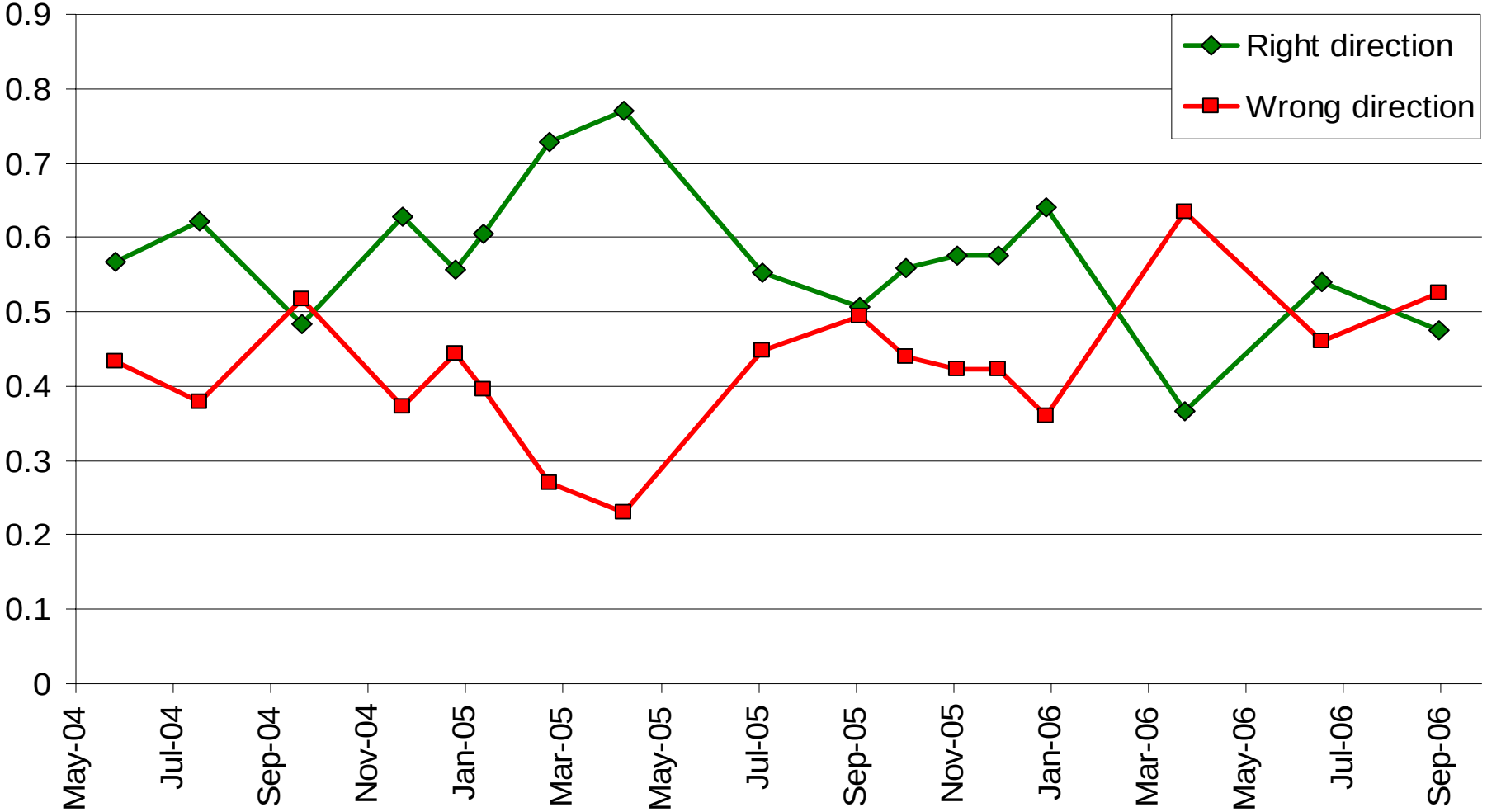
- Model reports (Mid-April)
    - MLR: 42.5%
    - GLM: 42.8%

Model of Combat and Public Resolve

- Connects Blue Attrition to Blue Entropy
- Potentially represents population entropy



Iraqi Public Opinion Survey



- Do you feel that Iraq is generally heading in the right direction or the wrong direction?
- Survey of Iraqi Public Opinion (World Public Opinion.ORG)

Percents based on responds with an opinion

Conclusions

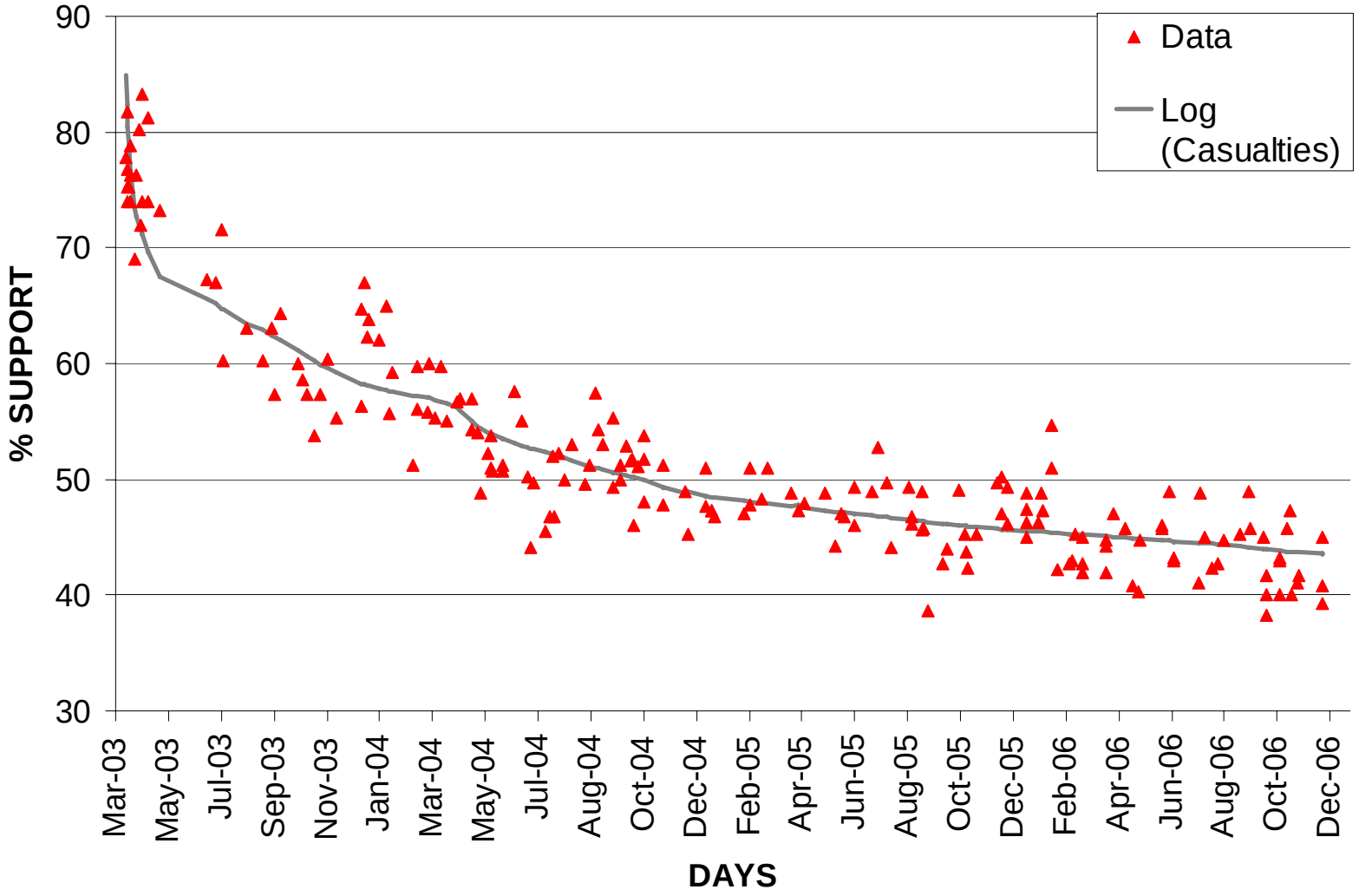
- Model of Iraq and first 5 years of Vietnam are about the same
- As casualties increase by an order of magnitude; the public support drops by 15% (Korea, Vietnam, Iraq)
- Constructed theoretical modeling framework of public resolve
  - Founded on empirical evidence of four key factors
    - Log_{10} of Casualties
    - Days into war
    - Number of daily attacks by insurgents
    - Number of insurgents (captured / killed): only positive
- Provides a capability to evaluate impacts of conflict on public resolve
- Future research will connect public opinion to combat effects

Back-up

Questions?

Mueller Model with Iraq Data

- Still valid for Iraq



Williams Procedure

1) Let overdispersion factor ϕ=0 and all weights w_i=1, evaluate the Pearson deviance (χ^2)

of the saturated model, where $\textit{Pearson Deviance} = \chi^2 = \sum_{i=1}^{n} \frac{w_i \left(y_i - n_i \hat{p}_i\right)^2}{n_i \hat{p}_i \left(1 - \hat{p}_i\right)}$.

2) Compare χ^2 with $\chi^2_{(n-p)}$. If χ^2 is unacceptably large, conclude ϕ>0 and estimate

$\hat{\phi} = X^2 - \frac{\sum_{i=1}^{n} w_i \left(1 - w_i v_i d_i\right)}{\sum_{i=1}^{n} w_i \left(n_i - 1\right)\left(1 - w_i v_i d_i\right)}$, where $v_i = n_i p_i \left(1 - p_i\right)$ and d_i is the i^{th} diagonal element of the variance-covariance matrix.

3) Let the new weights be, $w_i = \left(1 + \left(n_i - 1\right)\hat{\phi}\right)^{-1}$ and estimate $\boldsymbol{\beta}$ and recalculate χ^2.

4) If χ^2 is close to the degrees of freedom (n - p) quit, else recalculate $\hat{\phi}$ and return to step 3.

What was the question?

- Public support based on polls from ABC, CBS, PEW & Gallop
- Investigated both support (those in favor) and opposed
- ABC asked: "All in all, considering the costs to the United States versus the benefits to the United States, do you think the war with Iraq was worth fighting, or not?"
- CBS asked: "Looking back, do you think the United States did the right thing in taking military action against Iraq, or should the U.S. have stayed out?"
- PEW asked: "Do you think the U.S. made the right decision or the wrong decision in using military force against Iraq?"
- Gallop asked: "In view of the developments since we first sent our troops to Iraq, do you think the United States made a mistake in sending troops to Iraq, or not?"
- This is used by each organization to gauge if the population supports the war